

STRUCTURE AND DECAY PROPERTIES OF SPIN-DIPOLE GIANT RESONANCES WITHIN A SEMIMICROSCOPICAL APPROACH

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Abstract

A semimicroscopical approach is applied to calculate: (i) strength functions for the charge-exchange spin-dipole giant resonances in the ^{208}Pb parent nucleus; (ii) partial and total branching ratios for the direct proton decay of the resonance in ^{208}Bi . The approach is based on continuum-RPA calculations of corresponding reaction-amplitudes and phenomenological description of the doorway-state coupling to many-quasiparticle configurations. The only adjustable parameter needed for the description is found by comparison of the calculated and experimental total widths of the resonance. Other model parameters used in calculations are taken from independent data. The calculated total branching ratio is found to be in reasonable agreement with the experimental value.

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1 Introduction

The intensive experimental and theoretical studies of the direct nucleon decay of various giant resonances have been undertaken in recent years in an attempt to understand better the interplay of single-quasiparticle, collective and many-quasiparticle modes of nuclear motion. This work was stimulated by the appearance of experimental data on (total) branching ratio for the proton decay of the spin-dipole giant resonance of the (pn^{-1}) - type ($SDR^{(-)}$) in ^{208}Bi [1]. The branching ratio was deduced from the analysis of the $^{208}\text{Pb}(^3\text{He},t)^{208}\text{Bi}$ and $^{208}\text{Pb}(^3\text{He},tp)^{207}\text{Pb}$ reactions cross sections at $E(^3\text{He})=450$ MeV. Being related to the spin-flip giant resonance, this branching ratio is a valuable addition to the experimental data on partial proton widths of the Gamow-Teller resonance (GTR), which were also obtained in Ref. [1].

The main aim of this work is to calculate the above-mentioned branching ratio within the approach proposed previously [2,3] and called, for brevity sake, the semimicroscopical approach. Another aim is to analyze the strength functions of the inverse resonances ($SDR^{(+)}$) in ^{208}Tl within the same approach. The basic points of the semimicroscopical approach are the following: (i) continuum-RPA (CRPA) calculation of the reaction amplitudes corresponding to the excitation of the considered GR by an external single-particle field; (ii) Breit-Wigner parameterization of the calculated amplitudes to deduce the parameters of those particle-hole-type doorway states, which form the GR; (iii) a phenomenological description (with averaging over the energy) of the doorway-state coupling to many-quasiparticle configurations. In the considered case the only adjustable parameter needed for the description is found by comparison of the calculated and experimental total widths of the $SDR^{(-)}$. The phenomenological mean field and the isovector part of the Landau-Migdal particle-hole interaction are used in the calculations. The calculation results are compared with both the experimental data taken from Ref. [1] and results of some previous calculations of the GTR partial proton widths [4].

2 Calculation scheme

CRPA equations.

All CRPA-equations used in this work are given in the form accepted within the finite Fermi-system theory [5]. Let $\hat{V}_{JLSM}^{(\mp)} = \sum_a V_{JLSM}^{(\mp)}(x_a)$, $V_{JLSM}^{(\mp)}(x_a) = V(r)T_{JLSM}(\vec{n})\tau^{(\mp)}$ be an external single-particle field acting upon the nucleus in the process of GR excitation. Here, $T_{JLSM}(\vec{n})$ is the irreducible spin-angular tensor operator of rank J , $\tau^{(\mp)}, \tau^{(3)}$ are the Pauli matrices acting in the isospin space. Bearing in mind the $SDR^{(\mp)}$ excitation we put below

$J = 0, 1, 2$; $L = S = 1$ (for the *GTR* $J = S = 1, L = 0$). Within the CRPA the strength function ("inclusive reaction" cross section) is defined by the following expression:

$$S_{V,J}^{(\mp)}(\omega) = -\frac{1}{\pi} \text{Im} P_{V,J}^{(\mp)}(\omega) = -\frac{1}{\pi} \text{Im} \int V(r) A_J^{(\mp)}(r, r'; \omega) \tilde{V}_J^{(\mp)}(r', \omega) dr dr', \quad (1)$$

where $P_{V,J}^{(\mp)}(\omega)$ is the nuclear polarizability ("forward scattering" amplitude) corresponding to the given external field, $(rr')^{-2} A_J^{(\mp)}(r, r'; \omega)$ is the radial part of free particle-hole propagator carrying quantum numbers J, L and S , ω is the excitation energy measured from the parent-nucleus ground-state energy and $\tilde{V}_J^{(\mp)}$ are the so-called effective fields. They satisfy the integral equations:

$$\tilde{V}_J^{(\mp)}(r, \omega) = V(r) + \frac{2G'}{r^2} \int A_J^{(\mp)}(r, r'; \omega) \tilde{V}_J^{(\mp)}(r', \omega) dr', \quad (2)$$

where G' is the intensity of the spin-isospin part of Landau-Migdal particle-hole interaction $(F' + G' \vec{\sigma}_1 \vec{\sigma}_2)(\vec{\tau}_1 \vec{\tau}_2) \cdot \delta(\vec{r}_1 - \vec{r}_2)$. Propagators $A_J^{(\mp)}$ can be expressed in terms of: (i) occupation numbers n_μ^α ($\alpha = n, p$), (ii) radial bound-state single-particle wave functions $r^{-1} \chi_\mu^\alpha(r)$ ($\mu = \varepsilon_\mu, j_\mu, l_\mu$) and Green functions $g_{(\nu)}^\alpha(r, r'; \varepsilon)$ of the radial single-particle Schrodinger equations ($(\nu) = j_\nu, l_\nu$). The expressions for $A_J^{(\mp)}$ are well-known and given, for instance, in Ref. [2] for the case of the *GTR* description.

The alternative representation of $S_{V,J}^{(\mp)}$, which is more convenient for consideration of continuum problems, follows from Eqs. (1), (2) (below superscripts (\mp) are sometimes omitted):

$$S_{V,J}(\omega) = -\frac{1}{\pi} \text{Im} \int \tilde{V}_J^*(r, \omega) A_J(r, r'; \omega) \tilde{V}_J(r', \omega) dr dr' = \sum_{\mu, (\nu)} |M_c(\omega)|^2. \quad (3)$$

The expression for the "reaction-amplitudes" $M_c^{(-)}$ has the form:

$$M_c^{(-)} = (n_\mu^n)^{1/2} t_{(\nu)(\mu)}^{JLS} \int \chi_{\varepsilon(\nu)}^p(r) \tilde{V}_J^{(-)}(r, \omega) \chi_\mu^n(r) dr. \quad (4)$$

Here, $t_{(\nu)(\mu)}^{JLS} = (2J+1)^{-1/2} \langle (\nu) || T_{JLS} || (\mu) \rangle$ is the kinematic factor, $r^{-1} \chi_{\varepsilon(\nu)}^p(r)$ is the normalized to the δ -function of energy radial continuum-state (real) wave function for the escaping proton with energy $\varepsilon = \omega + \varepsilon_\mu^n$, $c = J, L, S$, $(\nu), \mu$ could be considered as a set the reaction-channel quantum numbers. A similar expression takes place for amplitudes $M_c^{(+)}$.

Doorway-state parameters.

In the vicinity of the GR with not-too-large excitation energy the reaction

amplitudes calculated within the CRPA exhibit narrow, as a rule nonoverlapping, resonances. These resonances correspond to the particle-hole-type doorway states forming the GR. Breit-Wigner parameterization of the amplitudes $P_{V,J}$ and M_c

$$P_{V,J}(\omega) = \sum_g \frac{R_g}{\omega - \omega_g + \frac{i}{2}\Gamma_g^\uparrow} ; \quad M_c(\omega) = \frac{1}{\sqrt{2\pi}} e^{i\xi_c(\omega)} \sum_g \frac{R_g^{1/2} (\Gamma_{gc}^\uparrow)^{1/2}}{\omega - \omega_g + \frac{i}{2}\Gamma_g^\uparrow} \quad (5)$$

allows one to deduce the doorway-state parameters: energy ω_g , partial strength R_g , partial and total escape widths Γ_{gc}^\uparrow and Γ_g^\uparrow , respectively. The possibility to use the above parameterization can be checked by satisfying the equality $\Gamma_g^\uparrow = \sum_{\mu,(\nu)} \Gamma_{gc}^\uparrow$, which follows from Eqs. (1), (3), (5). The phases $\xi_c(\omega)$ in Eq. (5) are smooth functions of energy. Note that amplitudes $R_g^{1/2}, (\Gamma_{gc}^\uparrow)^{1/2}$ are not sign-fixed quantities and only their products found with the help of parameterization (5) are used below.

The integrals $R_{V,J}^{(\mp)} = \int_{\omega_1}^{\omega_2} S_{V,J}^{(\mp)}(\omega) d\omega$ calculated with the use of Eq. (3) for a rather wide excitation energy interval $\delta_{12} = \omega_2 - \omega_1$ define the GR total strength, so that ratios $x_g = R_g/R_{V,J}$ are the relative partial strengths. Calculations of the above strength functions can be checked by a comparison of difference $R_{V,J}^{(-)} - R_{V,J}^{(+)}$ and only slightly model-dependent sum rule $(SR)_V = \int \rho^{(-)} V^2(r) r^2 dr$, where $\rho^{(-)} = \rho^n - \rho^p$ is the neutron-excess density. Hence the ratios $x_{V,J} = (R_{V,J}^{(-)} - R_{V,J}^{(+)})/(SR)_V$ of above quantities should be close to unity provided that interval δ_{12} is sufficiently large. In the case of *GTR* and *SDR* ratios $B_{V,J} = R_{V,J}^{(+)} / R_{V,J}^{(-)}$ calculated for a long-wave external field $V(r)$ are expected to be small for nuclei with large neutron excess due to Pauli blocking.

Doorway-state coupling to many-quasiparticle configurations.

This coupling leads to doorway-state spreading and formation of the GR as a single resonance in the energy dependence of energy-averaged reaction cross sections. We take this coupling into consideration phenomenologically by independently spreading each doorway-state resonance [2,3]. It means that the transition to the energy-averaged reaction amplitudes $\bar{P}_{V,J}$ and \bar{M}_c can be realized by the following substitution in Eqs. (5): $\omega - \omega_g + \frac{i}{2}\Gamma_g^\uparrow \rightarrow \omega - \omega_g + \frac{i}{2}\Gamma_g$, where $\Gamma_g = \Gamma_g^\uparrow + \Gamma_g^\downarrow$. The doorway-state spreading width Γ_g^\downarrow is considered as the only adjustable parameter of the semimicroscopical approach. It can be found by equating the total width Γ (dependent on Γ_g^\downarrow) of the calculated energy-averaged strength function of the $SDR^{(-)}$

$$\bar{S}_V^{(-)}(\omega) = \sum_{J=0,1,2} (2J+1) \bar{S}_{V,J}^{(-)}(\omega) ; \quad \bar{S}_{V,J}^{(-)}(\omega) = -\frac{1}{\pi} \text{Im} \sum_g \frac{R_g}{\omega - \omega_g + \frac{i}{2}\Gamma_g} \quad (6)$$

to the total width Γ^{exp} of the $SDR^{(-)}$ in the experimental inclusive reaction cross section. Because this cross section is parameterized by a single-level formula [1], we approximate calculated strength function (6) by the same formula:

$$\bar{S}_V^{(-)} \rightarrow \frac{1}{2\pi} \cdot \frac{R_V^{(-)}\Gamma}{(\omega - \omega_m)^2 + \frac{1}{4}\Gamma^2}, \quad (7)$$

where $R_V^{(-)} = \int_{\omega_1}^{\omega_2} S_V^{(-)}(\omega) d\omega$ and ω_m are, respectively, the calculated total strength and mean excitation energy of the $SDR^{(-)}$.

Because each doorway-state resonance in the energy dependence of amplitudes $\bar{M}_c(\omega)$ becomes rather broad, it is necessary to take also into account changing the penetrability of the potential barrier for escaping protons over the resonance. It can be done as follows [4]:

$$|\bar{M}_c(\omega)|^2 = \frac{1}{2\pi} \left| \sum_g \frac{R_g^{1/2} (\bar{\Gamma}_{gc}^\dagger)^{1/2}}{\omega - \omega_g + \frac{i}{2}\Gamma_g} \right|^2; \quad \bar{\Gamma}_{gc}^\dagger = \Gamma_{gc}^\dagger \frac{\bar{P}_{g(\nu)}}{P_{(\nu)}(\varepsilon_{g\mu})}. \quad (8)$$

Here, $\varepsilon_{g\mu} = \omega_g + \varepsilon_\mu^n$, $\bar{P}_{g(\nu)}$ is the penetrability averaged over the resonance:

$$\bar{P}_{g(\nu)} = \frac{1}{\sqrt{2\pi}\sigma_g} \int P_{(\nu)}(\varepsilon) \exp\left(-\frac{(\varepsilon - \varepsilon_{g\mu})^2}{2\sigma_g^2}\right) d\varepsilon; \quad \sigma_g = \Gamma_g/2.35. \quad (9)$$

Thus, the energy-averaged partial cross sections $\bar{\sigma}_\mu(\omega) = \sum_{(\nu)} |\bar{M}_c(\omega)|^2$ (the fluctuational part of these cross sections is neglected) can be calculated without the use of any free parameters. Summation in the above equation is performed over the quantum numbers of the escaping proton, which are compatible with the selection rules for the spin-dipole transitions. Cross section $\bar{\sigma}_\mu(\omega)$ corresponds to population of single-hole state μ^{-1} in the product nucleus after the $SDR^{(-)}$ proton decay.

Branching ratios.

The $SDR^{(-)}$ branching ratios and partial widths for the direct proton decay are defined as follows:

$$b_\mu = \int \sum_{J=0,1,2} (2J+1) \bar{\sigma}_\mu^J(\omega) d\omega \Big/ \int \bar{S}_V^{(-)}(\omega) d\omega, \quad \Gamma_\mu^\dagger = b_\mu \Gamma, \quad (10)$$

where $\bar{S}_V^{(-)}$ is defined by Eqs. (6). Note that this strength function, its single-level approximation (7) (parameters $R_V^{(-)}$ and ω_m), partial branching ratios

determined by Eqs. (8)–(10) are somewhat dependent on the energy interval δ_{12} used in the CRPA analysis. The choice of the interval is connected with description of corresponding experimental data (see next Section).

When only one doorway state corresponds to the considered GR (for instance, in case of the *GTR*) one can calculate the average partial escape widths of this GR directly with the help of Eq. (8): $\bar{\Gamma}_\mu^\dagger = \sum_{(\nu)} \bar{\Gamma}_c^\dagger$. Such a procedure was realized in Ref. [4]. To take the averaged potential-barrier penetrability more accurately into consideration in accordance with Eqs. (8), (9) we use the experimental one-hole state energies $\varepsilon_\mu^{n,\text{exp}}$ instead of calculated ones. For comparison with experimental data the calculated quantities b_μ or $\bar{\Gamma}_\mu^\dagger$ should be also multiplied by spectroscopic factors S_μ of the corresponding single-hole states in the product nucleus ^{207}Pb .

3 Calculation results

Choice of model parameters.

The nuclear mean field and particle-hole interaction are the input data for any RPA calculations. In the following the isoscalar part of the phenomenological nuclear mean field (including the spin-orbit interaction) is chosen in accordance with Ref. [2]. Only mean field amplitude U_0 is slightly increased (54.1 MeV instead of 53.3 MeV) to describe better the nucleon separation energies for ^{208}Pb . The strengths $(F', G') = (f', g') \cdot 300 \text{ MeV} \cdot \text{fm}^3$ of the isovector part of the Landau-Migdal particle-hole interaction are chosen as follows: $f' = 1.0$ (to describe the experimental difference of the neutron and proton separation energies in ^{208}Pb); $g' = 0.76$ (to describe the experimental energy of the *GTR* in ^{208}Bi [1]). The above strengths are close to those used in Refs. [2,4]. The isovector part $\frac{1}{2}\tau^{(3)}v(r)$ of the mean field is calculated in a self-consistent way (see e.g. Ref. [6]): $v(r) = 2F'\varrho^{(-)}$. The nuclear Coulomb field is calculated in Hartree approximation via the proton density ϱ^p .

Calculation results for the ^{208}Pb parent nucleus.

The nuclear mean field chosen above allows one to describe satisfactorily the single-quasiparticle spectrum of the ^{208}Pb parent nucleus. The calculated neutron single-hole spectrum (energies ε_μ^n) is given in the Table 1 in comparison with the experimental one (energies $\varepsilon_\mu^{n,\text{exp}}$). All experimental quantities (except for the spectroscopic factors S_μ and neutron separation energy S_n) in this Table are taken from Ref. [1]. The values of S_μ and S_n are taken from Refs. [7] and [8], respectively.

In CRPA calculations of the $SDR^{(-)}$ and the *GTR* strength functions the radial dependence of the external field $V(r)$ is chosen as r/R and 1, re-

spectively (R is the nuclear radius). The GTR strength function is similar to that given in [2] and is not shown here. The $SDR^{(-)}$ strength functions $S_{V,J}^{(-)}(\omega^{(-)})$ are shown in Figs. 1a–1c up to the excitation energy $\omega_2^{(-)} = 35$ MeV ($\omega^{(-)} = \omega - \Delta_{\text{exp}}^{(-)}$ is the excitation energy measured from the ^{208}Bi ground-state energy, $\Delta_{\text{exp}}^{(-)} = 3.66$ MeV [8], $\Delta_{\text{calc}}^{(-)} = 3.30$ MeV).

In the case of $J^\pi = 0^-$ and $J^\pi = 1^-$ the main part of the total strength is exhausted by one doorway state (85% and 81%, respectively). In the case of $J^\pi = 2^-$ the calculated strength function exhibits an essential gross structure: eight doorway-state resonances exhaust 91% of the total strength (the relative strength of most resonances x_g (in %) is shown in Figs. 1a–1c). The ratios x_J and B_J are also given in these figures.

The energy-averaged strength functions $\bar{S}_V^{(-)}(\omega^{(-)})$ calculated according to equations (6) for three excitation-energy intervals $\delta_{12} = \omega_2^{(-)} - \omega_1^{(-)}$ ($\omega_2^{(-)} = 35$ MeV) are shown in Fig. 2. The chosen energies $\omega_1^{(-)}$ and the relative $SDR^{(-)}$ total strength x_δ are given in Table 2. The strength function calculated for each interval is approximated by single-level formula (7) so that adjustable parameter Γ^\downarrow (doorway-state spreading width) and calculated $SDR^{(-)}$ energy $\omega_m^{(-)}$ are determined by fitting to the $SDR^{(-)}$ experimental total width $\Gamma^{\text{exp}} = 8.4$ MeV [1]. These parameters are also given in Table 2.

Partial and total branching ratios for the $SDR^{(-)}$ proton decay are calculated according to equations (8)–(10). Calculated total branching ratios b depending on considered interval δ_{12} are given in Table 2. The use of $\omega_1^{(-)} = 17$ MeV seems to be reasonable for description of experimental data [1]. The reasons are the following: (i) calculated strength function $\bar{S}_V^{(-)}(\omega^{(-)})$ is satisfactorily described by single-level formula (see Fig. 2) used for approximation of the experimental inclusive reaction cross section [1]; (ii) the most part of the calculated $SDR^{(-)}$ strength ($x_\delta = 83\%$) is exhausted within this interval δ_{12} ; (iii) doorway-state spreading width $\Gamma^\downarrow = 4.7$ MeV found with the use of the experimental $SDR^{(-)}$ total width is reasonably greater than the experimental GTR spreading width $\Gamma_{GTR}^\downarrow = 3.54$ MeV [1]. The partial $SDR^{(-)}$ proton branching ratios b_μ ($b = 16.1\%$) calculated for the chosen excitation-energy interval are given in Table 1.

The averaged proton partial widths of the GTR $\bar{\Gamma}_\mu$ calculated according to Eqs. (8), (9) are also given in Table 1 in comparison with the experimental data. In above calculations the following expression for the penetrability is used [9]: $P(kR) = kR [F^2(kR) + G^2(kR)]^{-1}$, where $k^2 = 2m\varepsilon/\hbar^2$, F and G are well-known Coulomb functions.

The strength functions of the second $SDR^{(+)}$ are also calculated within CRPA for the external field $V(r) = r^3/R^3$. The mean excitation energy $\omega_m^{(+)}$ of this GR is found to be about 19.2 MeV ($\omega^{(+)} = \omega - \Delta_{\text{exp}}^{(+)}$ is the excitation energy

measured from the ^{208}Tl ground-state energy, $\Delta_{\text{exp}}^{(+)} = 4.21 \text{ MeV}$ [8], $\Delta_{\text{calc}}^{(+)} = 3.80 \text{ MeV}$).

Discussion of results.

The quality of the performed CRPA calculations of the $SDR^{(-)}$ spin-dipole strength functions is satisfactory, because calculated ratios $x_{V,J}$ are close to unity (Figs. 1a–1c). As expected, Pauli blocking leads to suppression of the $SDR^{(+)}$ spin-dipole strengths $R_J^{(+)} = B_J(1 - B_J)^{-1}x_J(SR)_V$ ($(SR)_V = 2.38$ for ^{208}Pb), because calculated ratios B_J are rather small (Figs. 1a–1c).

Calculated proton partial widths of the GTR are in a reasonable agreement with both the experimental data and the results of previous calculations performed within the same approach. The difference between two sets of $\bar{\Gamma}_{\mu}^{\uparrow}$ is explained by the self-consistent calculation of the mean Coulomb field, by the small difference of model parameters used in calculation and by the use in this work of spectroscopic factors S_{μ} for final states in ^{207}Pb .

The calculated mean excitation energy of the second $SDR^{(+)}$ in ^{208}Tl $\omega^{(+)} = 19.2 \text{ MeV}$ can be considered as a guide for an experimental search of this GR.

The calculated mean $SDR^{(-)}$ energy $\omega_m^{(-)} = 23.1 \text{ MeV}$ is in acceptable agreement with experimental energy $\omega_{\text{exp}}^{(-)} = 21.1 \pm 0.8 \text{ MeV}$ [1]. However, the main result of this work consists in a reasonable description of the $SDR^{(-)}$ total branching ratio ($b = 16.1\%$, $b^{\text{exp}} = 14.1 \pm 4.2\%$ [1]) or of the $SDR^{(-)}$ total proton width ($\bar{\Gamma}_{\text{tot}}^{\uparrow} = 1.35 \text{ MeV}$, $\bar{\Gamma}_{\text{tot}}^{\uparrow\text{exp}} = 1.18 \pm 0.35 \text{ MeV}$ [1]).

4 Conclusion and acknowledgments

In this work the semimicroscopical approach is applied to calculate the branching ratios for the direct proton decay of the $SDR^{(-)}$ in ^{208}Bi . A reasonable description of the experimental data on the proton total branching ratio is obtained. Previous calculations on the partial proton widths of the GTR in ^{208}Bi are refined. The energy position of the second $SDR^{(+)}$ in ^{208}Tl is predicted.

It will be possible to perform more detailed comparison of the results obtained within the semimicroscopical approach and experimental data provided that the experimental partial proton branching ratios b_{μ} will become available and different $SDR^{(-)}$ spin components will be separated [10]. In this connection further experimental and theoretical studies of proton and γ - decays of the $SDR^{(-)}$ seem to be very promising.

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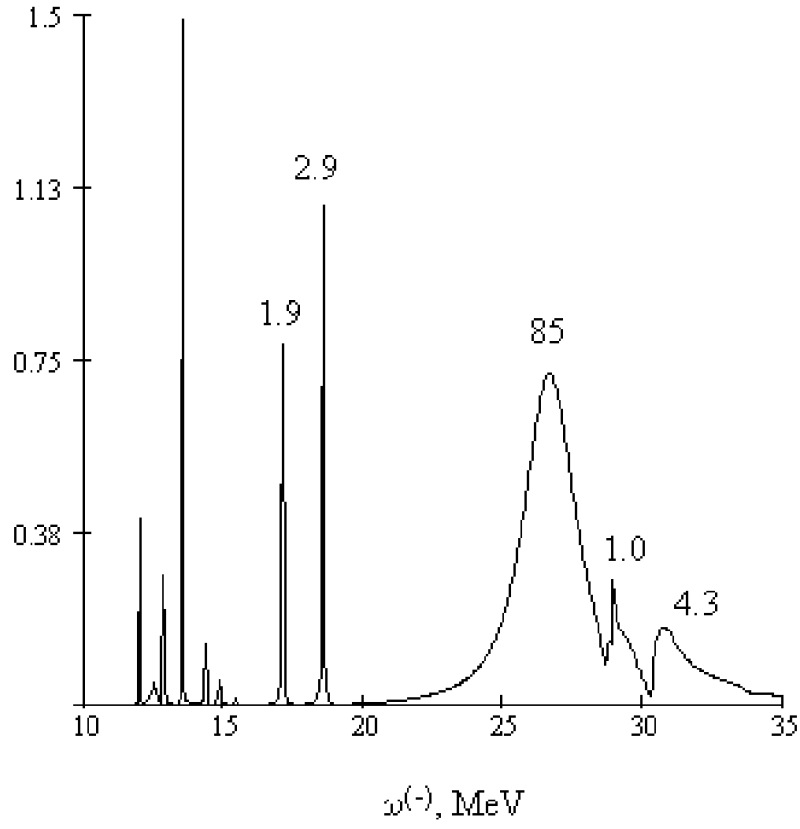


Figure 1a: Spin-dipole strength function calculated within CRPA for the $J^\pi = 0^-$ - component of the $SDR^{(-)}$ in ^{208}Bi . The relative strengths (in %) of doorway states are also shown. $x=0.98$, $B=14\%$.

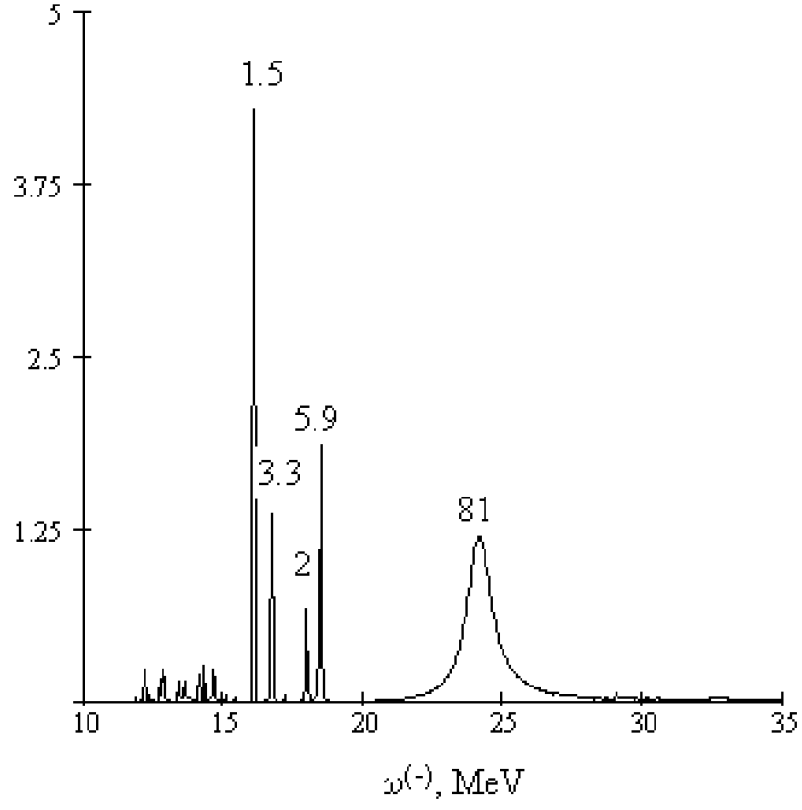


Figure 1b: The same as in **Fig. 1a**, but for $J^\pi = 1^-$. $x=0.98$, $B=8\%$.

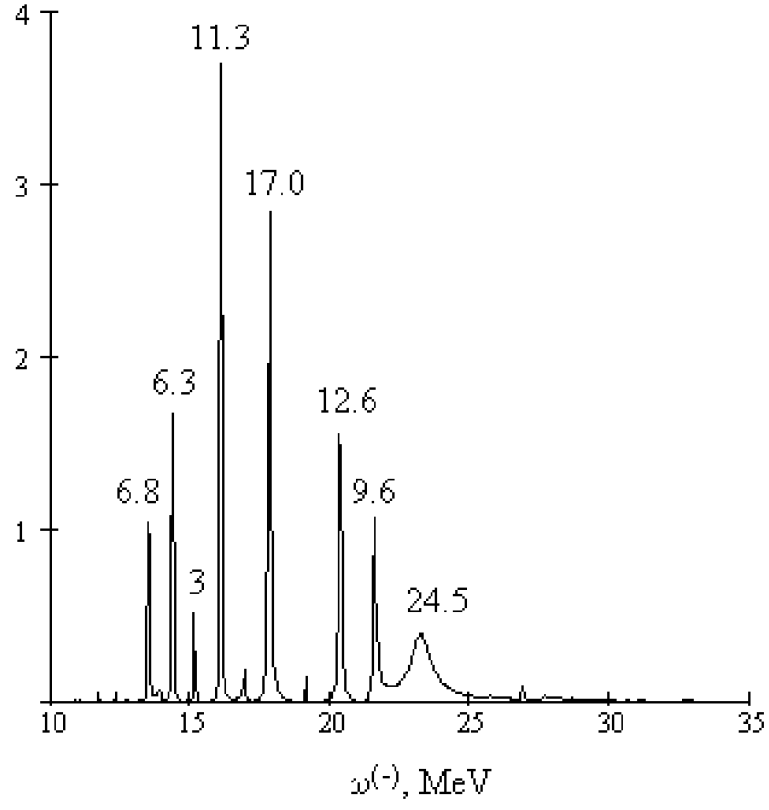


Figure 1c: The same as in **Fig. 1a**, but for $J^\pi = 2^-$. $x=0.99$, $B=3.5\%$.

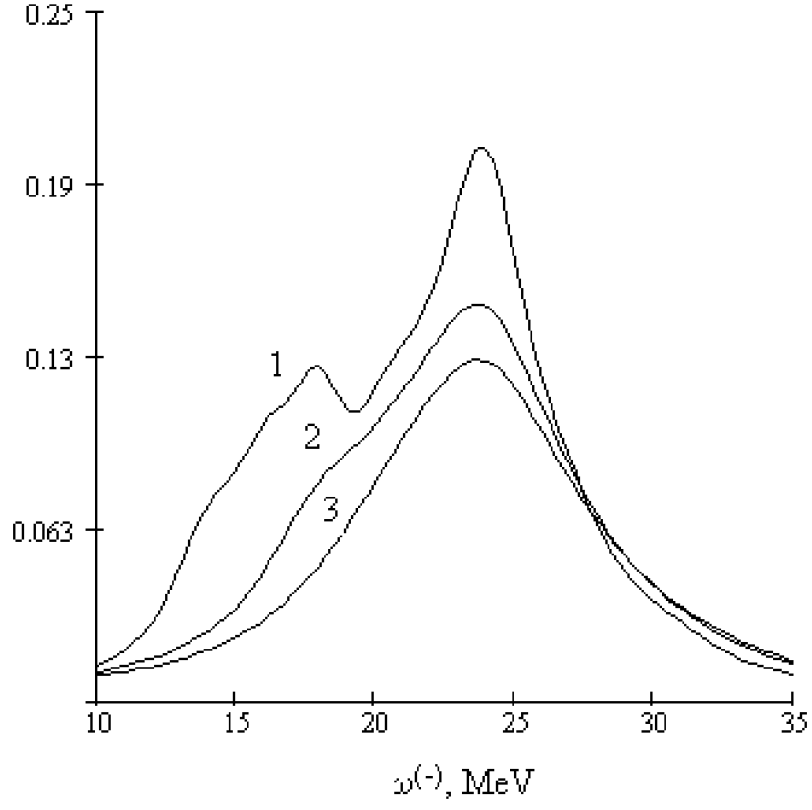


Figure 2: Energy-averaged strength functions $S_V^{(-)}(\omega^{(-)})$ calculated for different intervals δ_{12} : $\omega_1^{(-)}=13, 17$ and 18 MeV (curves 1, 2 and 3, respectively).

Table 1

Calculated escape widths and branching ratios for proton decay of the *GTR* and the *SDR*⁽⁻⁾ in ²⁰⁸Bi. Rather small contribution of deep-hole states to the calculated *b* value ($\sum_{\mu'} b_{\mu'} = 1.94\%$) is not shown. Experimental data contain also $\Gamma_{\text{tot}}^{\uparrow} = 1.18 \pm 0.35$ MeV and $b = 14.1 \pm 4.2\%$ for the *SDR*⁽⁻⁾.

μ^{-1}	S_{μ} Ref. [7]	$-\varepsilon_{\mu}^n$, MeV	$-\varepsilon_{\mu}^{n \text{ exp}}$ MeV	<i>GTR</i>			<i>SDR</i> ⁽⁻⁾	
				$S_{\mu}^{-1}\bar{\Gamma}_{\mu}^{\uparrow}$, keV Ref. [4]	$\bar{\Gamma}_{\mu}^{\uparrow}$, keV this work	$\bar{\Gamma}_{\mu}^{\uparrow}$, keV exp	$\bar{\Gamma}_{\mu}^{\uparrow}$, keV	b_{μ} , %
$3p_{\frac{1}{2}}$	1.1	7.36	7.37	43	60.8	58.4±19.8	88.4	1.05
$2f_{\frac{5}{2}}$	0.98	8.14	7.94	48	54.0	incl. in $p_{\frac{3}{2}}$	163.2	1.94
$3p_{\frac{3}{2}}$	1.0	8.59	8.27	35	50.5	101.5±31.3	183.1	2.18
$1i_{\frac{13}{2}}$	0.91	10.19	9.00	0.78	0.73	8.3±9.4	318.8	3.80
$2f_{\frac{7}{2}}$	0.7	11.22	9.71	8.9	5.95	15.6±7.6	337.3	4.02
$1h_{\frac{9}{2}}$	0.61	11.49	10.78		0.19		98.6	1.17
total:				136	172.2	184±49	1354.1	16.1

Table should be put after the first mention in the text.

Table 2

Dependence of the $SDR^{(-)}$ parameters on the choice of excitation-energy interval $\delta_{12} = \omega_2^{(-)} - \omega_1^{(-)}$ ($\omega_2^{(-)} = 35 \text{ MeV}$) in the analysis of strength functions $S_{V,J}^{(-)}(\omega^{(-)})$.

$\omega_1^{(-)}, [\text{MeV}]$	x_δ	$\Gamma^\downarrow, [\text{MeV}]$	$\omega_m^{(-)}, [\text{MeV}]$	$b, [\%]$
13	1	2.5	22.7	21.2
17	0.83	4.7	23.1	16.1
18	0.73	5.8	23.6	15.5

Table should be put after the first mention in the text.